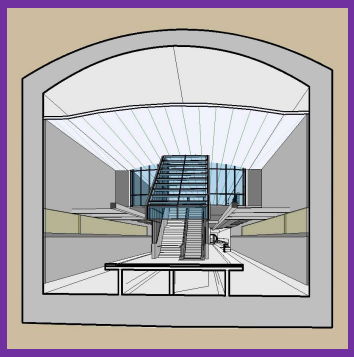
LOS ANGELES COUNTY METROPOLITAN TRANSPORTATION AUTHORITY

WESTSIDE PURPLE LINE EXTENSION PROJECT, SECTION 2

ADVANCED PRELIMINARY ENGINEERING

Contract No. PS-4350-2000


Section 2 Geotechnical Fault Investigations Summary Memorandum

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1.0 INTRODUCTION

This memorandum has been prepared for Section 2 of the proposed Westside Purple Line Extension project (WPLE) (formerly referred to as the Westside Subway Extension) as part of the Advanced Preliminary Engineering (Adv. PE) phase for the Los Angeles County Metropolitan Transportation Authority (Metro). Section 2 of the WPLE Project will extend from the western "End Structure" of the Wilshire La Cienega Station (at the western end of Section 1) to the eastern "End Structure" of the Century City Constellation Station. Section 2 will include two stations: the Wilshire / Rodeo Station, and the Century City Constellation Station, and tunnels extending from Section 1 to the Century City Constellation Station. As part of geotechnical investigations performed for Section 2, Metro has performed Fault Investigations to evaluate the potential for active faults crossing the alignment. In addition, other entities have performed investigations to evaluate the potential for active faults crossing various properties in the area. This memorandum provides a summary of the Metro investigations and the investigations by others.

For the Final Environmental Impact Statement/Environmental Impact Report (EIS/EIR), investigations were carried out in the Century City area to address the Metro Board of Directors' motion to study tunneling safety in the WPLE alignment between Beverly Hills and Westwood, which includes the western portion of Section 2 and the eastern portion of Section 3. Two reports, the Westside Subway Extension Century City Area Tunneling Safety Report (Metro 2011a) and the Westside Subway Extension Century City Area Fault Investigation Report (Metro 2011b) were prepared to present the results of these studies in detail. This information was presented to the Metro Board of Directors on October 19, 2011, and was released to the general public on the same day. The Westside Subway Extension Geotechnical and Environmental Report (Metro 2011c) contains the soil boring logs, gas monitoring well diagrams, and detailed geologic profiles from these studies along the WPLE.

Since the Final EIS/EIR was certified, geologic fault investigations have been performed by other property owners on properties above and adjacent to the WPLE alignment by the property owners. The following subsurface geologic fault investigation reports are available to Metro for properties above and adjacent to the WPLE alignment:

- Fault Hazard Assessment of the West Beverly Hills Lineament, Beverly Hills High School (Leighton Consulting, Inc. [LCI] 2012a) – (along with the Response to Leighton Consulting Report [Metro 2012a]);
- Initial Response to California Geological Survey Review Comments, Fault Rupture Hazard Review, Beverly Hills High School (LCI 2012b);
- Second Response to California Geological Survey Review Comments, Fault Rupture Hazard Review, Beverly Hills High School (LCI 2012c);
- Addendum to Second Response to California Geological Survey Review Comments, Fault Rupture Hazard Review, Beverly Hills High School (LCI 2013);
- Report of Fault Rupture Hazard Investigation, 10000 Santa Monica Boulevard (Feffer Geological Consulting and Geocon West, Inc. [FGC and Geocon] 2012);
- Fault Trench Study, 10131 Constellation Boulevard, Century City (GeoKinetics Geotechnical & Environmental Engineers [GeoKinetics] 2013).

- Fault Rupture Hazard Investigation, 1802 Avenue of the Stars, 10250 Santa Monica Boulevard, 1930 Century Park West (Geocon West Inc. [Geocon] 2013);
- Report of Phase II Site-Specific Fault Rupture Investigation, 9900 Wilshire Boulevard (Geocon 2014);
- Geohazard Report, El Rodeo K-8 School (LCI, 2015); Updated Fault Hazard Assessment and Response to CGS Review Letter, El Rodeo K-8 School (LCI 2016);

The locations of these investigations are shown on Figure 1-1.

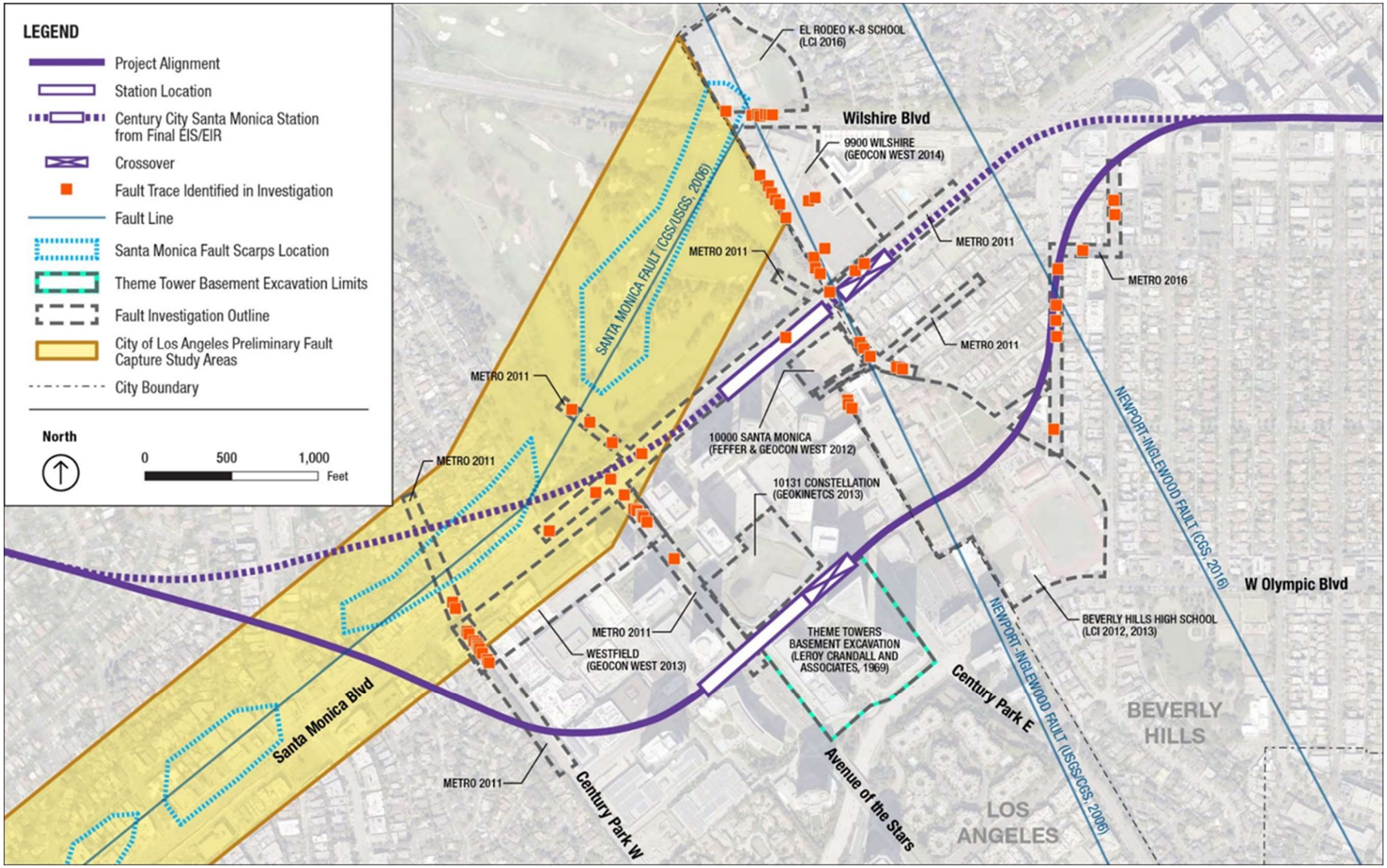
Since the Final EIS/EIR was certified, geologic fault evaluations based on review and interpretation of the existing data at the time of review have been performed by other property owners on properties above and adjacent to the WPLE alignment by the property owners. The following geologic fault evaluation reports are available to Metro for properties above and adjacent to the LPA alignment:

- Preliminary Literature and Geomorphic Evaluation of the Eastern Santa Monica Fault Zone, and Potential Impacts Associated with Fault Surface Rupture Relative to Proposed LA Metro Stations in Century City (Kenney GeoScience [KGS] 2011);
- Geomorphic, Structural and Stratigraphic Evaluation of the Eastern Santa Monica Fault Zone, and West Beverly Hills Lineament (KGS 2012);
- Hazard Assessment Study (Exponent, 2012a) – (along with Response to Hazard Assessment Study by Exponent [Metro 2012c], Response to Metro Comments [Exponent 2012b], and Reply to Exponent Responses [Metro 2012b]);
- Preliminary Review Comments of Century City Area Fault Investigation Report, Westside Subway Extension Project Century City and Beverly Hills Area (Shannon and Wilson 2012), (along with Response to Preliminary Review Comments of Century City Area Fault Investigation Report by Shannon & Wilson [Metro 2012d])
- Preliminary Revised Fault Map Based on Geomorphic, Structural and Stratigraphic Evaluation in the Century City/Cheviot Hills Area (KGS 2013);
- Structural and Stratigraphic Evaluation of the Century City-Cheviot Hills Area (KGS 2014); and
- Evaluation of Regional and Local Seismic Issues within the Beverly Hills Unified School District and their Public and Scientific Issues (KGS and PrimeSource Project Management LLC [PrimeSource] 2016)

Following the completion of the Final EIS/EIR, the City of Beverly Hills and/or Beverly Hills High School (BHHS) prepared a series of letters to Metro regarding Metro's interpretation of the data in the Final EIS/EIR.

In addition, the City of Los Angeles established Preliminary Fault Rupture Study Areas (PFRSA) in 2015, where fault investigations are required. The PFRSA in the Century City area includes the Santa Monica fault generally along Santa Monica Boulevard between the Cities of Santa Monica and Beverly Hills (City of LA 2015). The location is shown on Figure 1-1.

Figure 1-1: Fault Investigations along Section 2 of the WPLE



Finally the California Geological Survey (CGS) has published revised geologic maps of the Los Angeles 30 x 60 Minute Quadrangle that include the Century City and Beverly Hills area. The maps, although not produced for use in surface fault rupture hazard evaluation or seismic shaking hazard evaluation, depict a revised location of the Newport Inglewood Fault in the Century City/Beverly Hills area (CGS 2014, 2016). These maps show the Newport Inglewood fault extending northward into Beverly Hills at a location east of the location of their prior maps. The location is shown on Figure 1-1.

2.0 SUMMARY OF GEOLOGIC FAULT INVESTIGATIONS AND PUBLICATIONS

2.1 Century City Area Fault Investigation, Westside Subway Extension (Metro 2011b)

Metro conducted a subsurface investigation program to evaluate the potential for active fault zones to impact proposed locations of the WPLE Century City station and the location of crossings of active faults by the various WPLE tunnel alignments. No prior subsurface fault rupture hazard investigations had been performed in the immediate area.

Metro's subsurface fault rupture hazard investigation included 56 continuous core borings, 192 Cone Penetrometer Tests (CPTs), and 5 geophysical profiles along 7 transects in consideration of the mapped locations of the Santa Monica fault and the Newport Inglewood fault by the California Geological Survey and Dolan et al. The locations are shown on Figure 1-1. The Metro explorations were conducted almost entirely within public right-of-way due to the density of the built environment, disturbed original ground on non-right-of-way properties, which reduced the utility of explorations on those properties, and limited or restricted access to some properties. Trenching was not performed by Metro due to the extensive array of utilities in the public right-of-way and lack of permission to do so on properties where trenching might have been feasible.

Based on these data, a system of faults were interpreted associated with both the Santa Monica Fault and the Newport Inglewood Fault as presented on the Plate 3 map in the report. Organic materials suitable for Radiocarbon dating were not found, so the recency of faulting was not determined. As stated in the report, “as along most major fault systems, additional secondary fault strands and zones of possible distributed near-surface deformation are also likely to occur in association with these faults.” It was noted that there is a significant amount of uncertainty relative to the amount and location of faulting and ground deformation in complex fault zones. The conclusions of the report included direct evidence for no faulting at the location of the Century City Constellation Station, but evidence for complex faulting, potentially including multiple strands of active faults, at potential station locations along Santa Monica Boulevard.

2.2 Fault Rupture Hazard Review, Beverly Hills High School (LCI 2012a, 2012b, 2012c, and 2013)

LCI, with assistance from Earth Consultants International (ECI), performed several site-specific fault rupture hazard investigations to evaluate the presence of faulting associated with the fault systems mapped by CGS and interpreted by Metro. The LCI investigations, performed in two field phases, included excavation of 5 fault trenches, for a total of 800 lineal feet ranging in depth from 12 to 15 feet, 26 continuous core borings ranging from 105 to 180 feet in depth, and 12 CPTs ranging from 70 to 90 feet in depth. The locations are shown on Figure 1-1. The subsurface explorations were performed in two northeast-southwest-trending transects and one northwest-southeast-trending transect.

LCI interpreted four major stratigraphic units at the site: Benedict Canyon/Moreno Creek overbank flood deposits, Benedict Canyon Wash alluvial deposits, Older Alluvial Fan deposits, and San Pedro marine deposits.

Buried soils were interpreted within the alluvial deposits. Two techniques were utilized to estimate the ages of the alluvial stratigraphic units: OSL testing was performed, and subconsultants ECI and Soil Tectonics utilized soil development age dating techniques. Radiocarbon dating test results from charcoal samples were not considered reliable by LCI as being anomalously young compared to their soil development profiles, and according to LCI due to contamination with younger organics and by groundwater. LCI and ECI collaborated with Feffer Geological Consulting and Geocon West who were investigating the adjacent 10000 Santa Monica Boulevard site, which is adjacent to the BHHS campus on the north, and was being investigated by fault trenching in the same time period. The following table presents the results of their age estimates.

Table 2-1: Age Estimates

LCI Unit	Feffer-Geocon Unit	ECI Age Estimate (ka)	Helms Age Estimate (ka)	Best Age Estimate Based on ECI/Helms Work (Cumulative Age, ka)	OSL Age Results (ka)
Unit 1	Unit 1	40	30-60	30-60	52.3-66.3
	Unit 2		68-135	68-135	
Unit 2	Unit 4 Upper	24-60	30-70	54-130	
Unit 3	Unit 4 Lower	28-80	30-70	80-200	
Unit 3a	Unit 5	16-69	23-45	96-245	110-144
Unit 4	Unit 6		15-30	111-275	
Unit 5	Unit 7		15-30	126-305	100-128
Unit 6	Not Observed	17-30		143-335	121-159

Source: Modified from Addendum to Second Response to California Geological Survey Review Comments, Fault Rupture Hazard Review, Beverly Hills High School (LCI 2013)

A major fault zone was observed in LCI's Trench T-5 in the northern portion of the Beverly Hills High School campus. The apparent vertical component of offset along the faults of the zone of the top of the San Pedro formation, determined from continuous core borings, was estimated to be approximately 70 feet and is noted by Metro to be along trend with the fault south of Santa Monica Boulevard observed by Metro in their Transects 3 and 1. In the trench, observable vertical offsets along traces of this fault were documented to come up to near the base of the overlying modern artificial fill. Some of the faults were truncated by overlying alluvial deposits and colluvium. One fault "may affect the colluvium that is overlying the alluvium." LCI stated that the fault loses expression within the deposit, which they interpreted as a lack of renewal of the displacements and progressive destruction of the old fault fabric by pedogenic weathering and time. Some fractures were observed up to the top of the uppermost strata and capped by modern artificial fill. LCI concluded "the presence of strongly oriented illuviation argillans in the infilling material and intact weathered feldspar grains suggests stability since these fragile features formed." Based on these observations, LCI concluded this fault zone was not Holocene active.

Numerous fractures were observed in the other LCI trenches. A large number of fractures were observed in Trench T-2 in the near-surface, which were observed to have apparent vertical offsets and to be tilted. LCI interpreted these features to be the result of slope creep, tilting due to seismic ground shaking, and expansion-contraction of expansive soils. Fractures in other trenches, some with small

apparent vertical offsets, were not observed to extend to the top of Pleistocene sediments and were interpreted to not offset these sediments. LCI concluded that north-south trending faults, interpreted by Metro based on apparent offsets of bedding, were due to tilting of the beds and not faulting.

The northeast-southwest-trending fault appears to be associated with the Santa Monica fault system, and being south of other strands of the Santa Monica fault, would indicate the zone of faulting associated with the Santa Monica fault is wider than previously evaluated, particularly toward the eastern side of Century City. The Metro Section 2 WPLE fault investigation (Metro, 2016) concluded that the eastern extension of this fault zone is Holocene active. This interpretation of a greater width of the active Santa Monica fault zone indicates an increased uncertainty regarding faulting at potential Century City WPLE stations considered along Santa Monica Boulevard.

These studies did not include the geographic area near the Century City Constellation Station, and therefore does not provide commentary regarding faulting in the vicinity of the Century City Constellation Station. However, the investigation near the southern portion of the high school campus did not indicate the presence of faulting which would extend west toward the area of the Century City Constellation Station.

2.3 Report of Fault Rupture Hazard Investigation, 10000 Santa Monica Boulevard (FGC and Geocon 2012)

Feffer Geological Consulting and Geocon West performed a site-specific fault rupture hazard investigation to evaluate the potential of faulting associated with the northeast-southwest trending West Beverly Hills Lineament at 10000 Santa Monica Boulevard in Los Angeles, California. The investigation included excavation of one continuous southeast-northwest exploratory trench across the site to depths between 18 and 20 feet beneath the existing ground surface. The trench was excavated perpendicular to the trend of the CGS and interpreted faults and was approximately 300 feet in length. The location of this trench is depicted on Figure 1-1. The fault investigation was not oriented in a manner to address the potential presence of northeast-southwest faulting such as associated with the Santa Monica Fault.

The trench exposed deposits interpreted as Pleistocene age older alluvial deposits (designated within their report as Older Benedict Canyon Wash Deposits) and localized paleochannel deposits. The report states that the age of the Older Benedict Canyon Wash Deposits exposed in the trench are estimated to be between 208 and 345 ka and the paleochannel deposits are estimated to have a minimum age of 30 ka.

The report concluded that no faults were observed within the trench, based on the observation that geologic units encountered within the trench were laterally continuous and not offset by faulting. However, numerous steeply dipping “fractures” were observed within the trench that were vertically and laterally discontinuous. The report states that these fractures did not “exhibit features that could be indicative of faulting,” and concluded that these features are related to ground shaking and not fault surface rupture.

The orientation of the fault investigation trench was useful for evaluating northwest-southeast trending faults, such as associated with the mapped Newport-Inglewood fault, but was not oriented in such a manner to provide data regarding the presence of northeast-southwest trending faulting such as associated with the Santa Monica Fault. Therefore, the fault investigation at 10000 Santa Monica

Boulevard did not result in a reduction in the uncertainty regarding faulting associated with the Santa Monica Fault. This study did not include the geographic area near the Century City Constellation Station, and therefore does not provide commentary regarding faulting in the vicinity of the Century City Constellation Station.

2.4 Fault Rupture Hazard Investigation, 1802 Avenue of the Stars, 10250 Santa Monica Boulevard, 1930 Century Park West (Geocon 2013)

Geocon West performed a site-specific fault rupture hazard investigation to evaluate the presence of "postulated faults south of Santa Monica Boulevard identified as part of the Parsons Brinckerhoff study and confirm Holocene inactivity." The faults evaluated are the northeast-southwest trending faults located south of Santa Monica Boulevard.

The investigation included two transects, Transects A and B, consisting of drilling 15 closely-spaced continuously cored borings. Prior explorations from the Metro (2011b) report, 7 borings and 23 CPTs, were reviewed as part of their investigation. The horizontal spacing of the combined Geocon West and Metro borings ranged from 5 to 50 feet. The transects were oriented approximately perpendicular to the trend of the faults. Lettis Consultants International, Inc. provided technical oversight and peer review during the first half of Geocon West's investigation, which included an assessment of the local geomorphology to assist in the evaluation of landforms and soil age estimates of fluvial deposits encountered in Transect A. The investigation also included review of additional prior subsurface data in the vicinity of the site. The location of fault transects are depicted on the locations are shown on Figure 1-1.

The geologic units encountered in the explorations are described as younger alluvial and fluvial deposits of Holocene and latest Pleistocene age, older alluvial deposits of Pleistocene age, and terrestrial and marine sediments of the Pleistocene age Lakewood Formation. The San Pedro Formation was not encountered in the borings drilled by Geocon West, but was encountered in the previous Borings T1-B8 and T3-B6 (Metro 2011). John Helms, CEG was retained to assess the relative age of sediments encountered in selected borings. His work consisted of evaluating six vertical soil profiles to estimate the age of the soils within these profiles based on the degree of soil development observed. Relative age estimates for the younger alluvial deposits encountered in Transect A ranged from 58 ka to 135 ka. The relative age estimates along in Transect B for the younger alluvial deposits ranged from 92 ka to 191 ka for the younger alluvial deposits and 165 ka to 371 ka for the older alluvial deposits. Surficial soils were assigned dates ranging from 1 ka to 15ka. In addition to the overall dating of the general geologic units, age date estimates were determined for specific "marker buried soils," which are summarized on the following table from the Geocon 2013 report.

Table 2-2: Cross Section Unit Relative Ages

Transect	Boring	Soil Horizon	Profile Relative Age (ka)	Unit Relative Age (ka)1
A	1	Buried soil 1 and 2	34-68	34-127
	4	Buried soil 3 and 4	58-127	
	5	Buried soil 2 and 3	54-119	
	7	Buried soil 3 and 4	58-127	
B	1	Buried soil 1	9-30	9-30
	3	Buried soil 1	16-30	
B	1	Buried soil 2	39-89	31-89
	3	Buried soil 2	31-60	

Source: Modified from Fault Rupture Hazard Investigation, 1802 Avenue of the Stars, 10250 Santa Monica Boulevard, 1930 Century Park West (Geocon 2013)

The geomorphic analysis suggests the Transect A terrace surface is mid-Holocene to late Pleistocene.

Numerous faults, designated Faults A, B, C, D, and E, were interpreted within Transects A and B. Geocon West interpreted the uppermost stratigraphy and buried soils to be continuous across the transects. Based on their correlation of primary stratigraphy and buried soils, the soil-stratigraphic age estimates, and geomorphic analysis, Geocon West concluded the faults investigated are not Holocene active.

The investigation provided additional data on strands of the Santa Monica Fault south of Santa Monica Boulevard. With direct evidence of faulting, and possible differing interpretation regarding dates of activity of the fault, and the potential for Holocene fault rupture, there is considered to be risk associated with faulting of strands of the Santa Monica Fault in close proximity to potential locations for the Century Station WPLE station on Santa Monica Boulevard.

This study did not include the geographic area near the Century City Constellation Station, and therefore does not provide commentary regarding faulting in the vicinity of the Century City Constellation Station.

2.5 Fault Trench Study, 10131 Constellation Boulevard (GeoKinetics 2013)

GeoKinetics referenced an extensive geotechnical and geologic investigation previously performed at the 10131 Constellation Boulevard property in 2004 and 2011 and reported they found no evidence of geologically recent faulting. In 2012, KGS included a fault location map in his third party evaluation of geologic and seismic conditions with respect to the Metro project. That map illustrated three postulated east-west aligned fault segments trending towards, or onto, the northern portion of the property. GeoKinetics performed a site specific subsurface investigation to evaluate the locations of the postulated faults.

The subsurface investigation consisted of the excavation and logging of 3 trenches for a total of 90 lineal feet ranging in depth between 5 to 8 feet at the locations depicted on KGS's fault map. The locations are shown on Figure 1-1. The trenches encountered artificial fill overlying older alluvium. Based on the geologic literature, the older alluvium was considered to be Pleistocene, older than 11.7 ka. According to GeoKinetics, "No deformation, shearing, vertical offsets, horizontal offsets, or other potential

indications of fault activity were observed in any of the trenches." GeoKinetics concluded "geologically recent faulting is not present along the postulated fault traces."

With the location of the 10131 Constellation Boulevard site just north of the Century City Constellation Station, the GeoKinetics conclusion that there is no faulting at 10131 Constellation Boulevard at the locations postulated by KGS, is consistent with the other observations that there is no faulting observed in the immediate vicinity of the Century City Constellation Station. This study did not include the geographic area near Santa Monica Boulevard, and therefore does not provide commentary regarding faulting in the vicinity of potential locations for the Century City Station along Santa Monica Boulevard.

2.6 Phase II Site-Specific Fault Rupture Hazard Investigation, 9900 Wilshire Boulevard (Geocon 2014)

Geocon West performed a site-specific fault rupture hazard investigation to evaluate the presence of faulting associated with the northeast–southwest trending Santa Monica Fault and the northwest-southeast trending West Beverly Hills Lineament/Newport-Inglewood fault at 9900 Wilshire Boulevard in Beverly Hills, California.

The investigation incorporated a review of prior fault investigation data and reports, including the technical reports for the Metro (2011b) and LCI (2012a,b,c) investigations, the KGS (2012) regional assessment, previous geotechnical borings at the 9900 Wilshire site by MACTEC (2008), the stratigraphic age data from their previous fault rupture investigation at 10000 Santa Monica Boulevard (FGC and Geocon 2012) and the recently completed Westfield investigation (Geocon 2013). Also reviewed were groundwater level data (Antea Group, 2014; TRC, 2009) collected in nine groundwater monitoring wells at the adjacent service station property to the west of the site to confirm a groundwater barrier is present at that site and to compare general consistency of groundwater levels with those encountered in their borings at 9900 Wilshire. Two previous seismic reflection surveys performed by Geovision, 2012 were also reviewed.

The field investigation included 18 continuous core borings and 9 CPTs that were spaced from 20 to 40 feet apart along two transects (Transects A and B), and three trenches. The trenches, excavated in specific areas of previously interpreted faults, varied in depth from 7.5 to 17 feet deep, and had a total length of 532 feet. The locations of the borings, CPTs, and trenches for this site are depicted on Figure 1-1.

The geologic units encountered in the explorations were interpreted as younger alluvial deposits of Holocene age, older alluvial fan and older terrace deposits of Pleistocene age, and terrestrial and shallow marine/near shore sediments of the Pleistocene age Lakewood Formation.

John Helms, CEG was retained to assess relative age of sediments encountered in selected borings and within the trenches. His work consisted of evaluating eight representative soil profiles to estimate the age of the soils within these profiles based on the degree of soil development observed. Relative age estimates for the geologic units encountered are summarized in Table 2-3.

Table 2-3: Cross Section Unit Relative Ages

Stratigraphic Unit	Location	Relative Age Estimates (ka)
Qyt	Central portion of site (T-1 and T-2)	4-8
	Northern portion of site (B-7, B-11, and B-2b)	8-12
	Northwestern portion of site (B-13 and B-5b)	12-20
Qof	Southern portion of site (T-3 and B-3)	15-30
	Central portion of site (T-1 and T-2)	19-38
	Northern portion of site (B-7, B-11, and B-2b)	23-42
	Northwestern portion of site (B-13 and B-5b)	27-50
Qot1	Southern portion of site (T-3 and B-3)	23-48
	Central portion of site (T-1, T-2, and B-7)	27-50
	Northern portion of site (B-2b)	31-54
	Northwestern portion of site (B-13 and B-5b)	39-70
Qot2	Southern portion of site (B-3)	27-50
	Central portion of site (B-7)	35-62
	Northern portion of site (B-2b)	39-66
	Northwestern portion of site (B-5b)	43-78
Qot3+4	Southern portion of site (B-3)	31-58
	Central portion of site (B-7)	39-70
	Northern portion of site (B-2b)	43-74
	Northwestern portion of site (B-5b)	51-91
Qot5	Southern portion of site (B-3)	32-64
	Central portion of site (B-7 and B-11)	40-86
	Northern portion of site (B-2b)	44-78
	Northwestern portion of site (B-5b)	55-99
Qot6	Central portion of site (B-7 and B-11)	44-94
	Northern portion of site (B-2b)	48-86
Qoa1	Southern portion of site (B-3)	55-104
	Central portion of site (B-7)	59-112
	Northern portion of site (B-2b)	6-98
	Northwestern portion of site (B-5b)	63-111
Qoa2+3	Northern portion of site (B-2b)	79-140
	Northwestern portion of site (B-5b)	71-123

Source: Phase II Site-Specific Fault Rupture Hazard Investigation, 9900 Wilshire Boulevard (Geocon 2014)

Geocon West interpreted a number of faults within Transects A and B. Along Transect A, five faults were interpreted to offset Geocon West's Lakewood Formation and an overlying marker laminated sand unit. Metro, 2011b and LCI 2016 , interpreted these units to be older alluvium, not Lakewood Formation. Geocon West stated that 'these faults, designated Faults A through E, are a minimum age of 27 ka to 40 ka, based on estimated ages of the oldest unfaulted geologic units across these faults, and, therefore, are not active." Faults along Transect B, Faults G, H, and I, were interpreted to be active by Geocon West based on minimum estimated ages of faulted sediments (4 ka to 12 ka). Fault J was interpreted to be inactive, as it was interpreted to offset the Lakewood Formation sediments but not the overlying Older Terrace Deposits. Fault F was interpreted to offset Holocene sediments but the age of faulting could not be determined based on the lack of specific boring data west of this fault. Geocon West also stated that "other faults may exist west of Fault F but were not investigated by this study which focused on the 9900 Wilshire Site."

The investigation provided additional data on strands of the Santa Monica Fault north of Santa Monica Boulevard. Some of the faults were considered to be active, some were considered to have a date of last rupture that would place them older than would be considered active, and some of the faults had insufficient dating information to classify as active. With direct evidence of multiple strands of faulting, some of which were classified as active and some of which had uncertainty regarding activity, and with the fault strands encountered being in proximity to potential locations for the Century Station WPLE station on Santa Monica Boulevard, the results of the evaluation indicate a broad zone of faulting associated with the Santa Monica fault in the eastern portion of the Century City area, resulting in increased uncertainty regarding faulting at potential Century City WPLE stations along Santa Monica Boulevard. This study did not include the geographic area near the Century City Constellation Station, and therefore does not provide commentary regarding faulting in the vicinity of the Century City Constellation Station.

2.7 Fault Hazard Assessment, El Rodeo K8 School (LCI 2015 and 2016)

LCI, with assistance from ECI, performed a site-specific fault rupture hazard investigation to evaluate the presence of faulting associated with the north-south trending West Beverly Hills Lineament and northeast-southwest Santa Monica Fault at the El Rodeo K8 school campus. The investigation, performed in two field phases, included excavation of 5 fault trenches a total of approximately 477 lineal feet ranging in depth from 2.9 to 20 feet, and 23 continuous core borings ranging from 70 to 195 feet in depth. In addition, LCI and ECI logged 2 utility trenches excavated by others a total of 163.5 lineal feet ranging in depth from 3.5 to 10 feet. The locations are shown on Figure 1-1. They reviewed the logs of 4 continuous core borings and 9 CPTs performed by Geocon West for the 9900 Wilshire Boulevard property and 9 monitoring wells performed by others for a gas station adjacent to 9900 Wilshire.

LCI interpreted six major stratigraphic units at the site: modern and Holocene alluvium in the historical Moreno Creek channel, Holocene and Pleistocene Benedict Canyon Wash and Beverly Hills Plain alluvial and mudflow deposits, Pleistocene Benedict Canyon Wash (BCW 1) fluvial, alluvial fan, and mudflow deposits, Pleistocene Benedict Canyon Wash (BCW 2) fluvial, alluvial fan, and mudflow deposits, Pleistocene Cheviot Hills Deposits (CHD) alluvial and fluvial deposits, and San Pedro terrestrial to marine deposits.

Buried soils were identified within the Benedict Canyon Wash and Cheviot Hills deposits. ECI utilized soil development age dating techniques for the buried soils to estimate the age of the alluvial deposits. Six

profiles were described by ECI. Based on these profiles, age estimates for the deposits were developed: 36 ka to 100 ka for the Benedict Canyon Wash and Beverly Hills Plain deposits, 200 ka to 330 ka for the BCW1 deposits, 400 ka to 500 ka for the BCW2 deposits, and 500 ka to 1 million years old for the CHD deposits. The San Pedro deposits were estimated to be greater than 1 million years old based on geologic literature.

LCI interpreted three east-west trending faults to be present at depth within the El Rodeo campus, including two interpreted as active faults by Geocon West. The other east-west trending faults interpreted by Geocon West were reinterpreted by LCI to be the result of erosion or tilting of sediments since deposition. Additional features or discontinuities questioned by CGS were interpreted to be the result of erosional channeling or tilted sediments. Based on their interpreted ages and correlations of stratigraphic units, buried soils and erosional surfaces between borings and trenches, LCI concluded that the three interpreted faults were not Holocene active.

Specifically LCI concluded: "based on this supplemental investigation performed in response to CGS comments, it remains our opinion that no active faults are present on the campus of El Rodeo K8 School or its associated buildings. Specifically, we documented the presence of unbroken sediments and soils, dated by relative means to be a minimum 22 ka (minimum age for the relict profile at Station 0+10 in Trench FT-4), but more likely exceeding 200 ka."

The evaluation of faulting associated with the Santa Monica Fault zone resulted in a conclusion that the fault strands observed were not Holocene active. However, uncertainty remains regarding the age of most recent rupture on these strands. Based on these studies, the zone of faulting associated with the Santa Monica Fault extends a significant distance north of Santa Monica Boulevard as well south of Santa Monica Boulevard. This study did not include the geographic area near the Century City Constellation Station, and therefore does not provide commentary regarding faulting in the vicinity of the Century City Constellation Station.

2.8 Evaluation of Regional and Local Seismic Issues within the Beverly Hills Unified School District (KGS 2011, 2012, 2013, 2014, and KGS and PrimeSource [PSPM] 2016)

KGS has been evaluating the eastern Santa Monica fault zone for the Beverly Hills School District since the Metro 2011b report. KGS reviewed geologic literature, reviewed site specific investigations performed by others in 2011 through 2016, and performed geomorphic, structural and stratigraphic analyses of the compiled data as presented in the 2011, 2012, 2013, and 2014 reports. The 2014 report concentrated on the Century City-Cheviot Hills area. The 2016 report broadened the evaluation to the regional scale.

The KGS and PrimeSource 2016 report advances a model of the regional tectonic framework for the western Transverse Ranges Southern Boundary Fault System (TRSBFS), of which the Century City-Cheviot Hills area is a part. The conclusions are:

- A kinematic change occurred approximately 1 million years ago (~1 Ma) along the TRSBFS involving previously oblique blind reverse left-lateral fault zones transitioning to dominantly surface rupturing left-lateral strike-slip faults in the Beverly Hills Unified School District (BHUSD) region (KGS and PSPM 2016).

- That change, occurring 1 million years ago along the TRSBFS, led to the creation of the Potrero Canyon, Santa Monica Boulevard, and cross faults in the western Hollywood Basin to accommodate dominantly left-lateral motion. The near surface strand of the North Salt Lake Fault is proposed to have developed on the hanging wall of the deeper and older normal fault to accommodate dominantly left-lateral motion as well during the early Pleistocene. The Hollywood Fault transitioned from an oblique reverse left-lateral fault zone to accommodate dominantly left-lateral motion utilizing for the most part the same fault strands within its system (KGS 2016).
- The dominantly left-lateral strike-slip Santa Monica Boulevard Fault and western Hollywood Basin cross faults became inactive approximately 200 ka. Hence, these fault zones were active approximately 1 to 0.2 Ma (KGS and PSPM 2016).
- The Potrero Canyon Fault East was created within the past several hundred thousand years to accommodate dominantly left-lateral strike-slip motion no longer occurring on the Santa Monica Boulevard Fault and western Hollywood Basin cross faults. Some left-lateral motion may also be occurring on the blind western San Vicente and Rancho Faults (KGS and PSPM 2016).
- The northwest trending right-lateral strike-slip Newport-Inglewood Fault Zone migrated northward to latitudes of the Santa Monica Boulevard Fault Zone several hundred thousand years ago, but has subsequently "retracted" due to the development of the Potrero Canyon Fault East that essentially cut-off the northern most strands at the central southern Cheviot Hills. The southern Cheviot Hills began to be uplifted once the Newport-Inglewood Fault migrated northward along the eastern side of the hills (KGS and PSPM 2016).
- Compressional deformation (strain) that ceased approximately 1 Ma along the TRSBFS (Santa Monica Fault Zone) led to the development of new blind thrust faults (thrust ramps) west of the Newport-Inglewood Fault Zone. These include the Culver City Fault (thrust ramp) in the Beach Cities Region, and the Dume Fault East in Santa Monica Bay. Compressional deformation east of the Newport-Inglewood Fault Zone was accommodated on previously documented blind compressional faults in the northern Los Angeles Basin (KGS and PSPM 2016).
- The Santa Monica Fault North, Santa Monica Fault South, and eastern San Vicente Fault should be considered inactive, and are recommended to be removed from future seismic hazard analysis and fault data bases (KGS and PSPM 2016).
- The western Hollywood Fault Zone is designated as Regulatory Potentially Active herein, but evidence is provided suggesting that this portion of the Hollywood Fault Zone may be inactive (KGS and PSPM 2016).
- Proposed Cross Fault No.1 in the western Hollywood Basin has been determined to be Regulatory Inactive by fault investigations in Century City (KGS and PSPM 2016).
- Both the blind Rancho Fault in the southwestern Cheviot Hills, and western San Vicente Fault in the southern BHUSD may be active, possibly accommodating a component of left-lateral slip in addition to reverse thrust motion (oblique) (KGS and PSPM 2016).
- The San Vicente, Rancho, and North Salt Lake Fault Zones should be considered for future studies to ascertain their actual hazard (KGS and PSPM 2016).

The hypotheses advanced as part of the KGS/PrimeSource report were based on an evaluation of other studies performed and did not include additional investigative work. The conclusions that all of the

faults associated with the Santa Monica Fault zone and possibly the Hollywood Fault zone are inactive were predicated on a hypothesis that other faults have become active toward the south of the area and west of the Newport Inglewood fault, including several blind thrust faults at depth. This new set of hypotheses is dependent on the interpretation of the faulting associated with the Santa Monica Fault zone as inactive, in contradiction with several investigative studies performed along the length of the Santa Monica Fault. The Metro Section 2 WPLE fault investigation was not completed and therefore not available in the time frame of the KGS/PrimeSource analysis and conclusions of their 2016 report. Therefore, the findings of the Metro Section 2 WPLE fault investigation of Holocene surface rupture on faults crossing the tunnel alignment slightly south of Santa Monica Boulevard are new to KGS and PrimeSource and could influence their conclusions. Therefore considerable uncertainty regarding their most recent set of hypotheses exists. Nothing in these studies would indicate that there is faulting activity at the location of the Century City Constellation Station.

2.9 Hazard Assessment Study (Exponent, 2012a) – (along with Response to Hazard Assessment Study by Exponent [Metro, 2012c], Response to Metro Comments [Exponent, 2012b], and Reply to Exponent Responses [Metro, 2012b]) (2012)

The summary Included in Exponent's (Exponent, 2012a) review of the Westside Subway Extension Century City Area Tunneling Safety Report (Metro 2011a) and the Westside Subway Extension Century City Area Fault Investigation Report (Metro 2011b) were opinions regarding fault rupture hazards for the proposed Santa Monica Boulevard and Constellation Stations based on that review. Exponent's view was that the Constellation Boulevard station alternative was more favorable with regards to faulting hazards than the Santa Monica Boulevard Station alternative, however they suggested additional investigations consisting of trenching in Santa Monica Boulevard and adjacent properties for an alternative Santa Monica Boulevard Station location.

Noted in Metro's response (Metro 2012a) was that trenching in Santa Monica Boulevard and adjacent properties could not resolve fault presence or activity due to underground utility excavations destroying sediments necessary for evaluation and lack of access from adjacent property owners.

In Exponent's response to Metro, 2012a they continued to compare fault risk at Santa Monica Blvd vs their perceived gassy ground risk at Constellation.

In response, Metro and its Independent Review Panel (IRP) stated that Metro has developed an alignment at Century City Constellation Station where there are no active faults and the risks associated with soil gas are readily manageable as opposed to a station on Santa Monica Blvd where fault rupture risk exists and is unmanageable.

2.10 Preliminary Review Comments of Century City Area Fault Investigation Report, Westside Subway Extension Project Century City and Beverly Hills Area (Shannon and Wilson, 2012) - (along with Response to Preliminary Review Comments of Century City Area Fault Investigation Report by Shannon & Wilson [Metro, 2012d])

The summary Included in Shannon and Wilson's review of Metro, 2011w was the opinion that although no faults were found at the Constellation Station location, based on the data presented, additional

exploration was warranted. They concurred that the Santa Monica Station or a location to the east had risks due to the high probability of ground deformation stemming from earthquakes. They suggested consideration of a station location to the west if it could be demonstrated that active faults were not present in Santa Monica Boulevard.

2.11 Fault Investigation for Section 2 of Westside Purple Line Extension (Metro 2016b)

Metro conducted a subsurface investigation program to evaluate the location of crossings of active faults by the LPA tunnel associated with Section 2 of the various WPLE tunnel alignments. No prior subsurface fault rupture hazard investigations had been performed in the immediate area. The additional investigation for Section 2 of the WPLE included a transect (designated Transect 9) of explorations predominantly north-south along Lasky Drive, east along Charleville Boulevard and north along Spalding Drive in Beverly Hills, between Moreno Drive on the south and Wilshire Boulevard on the north. Transect 9 included 19 continuous core borings and 31 CPTs. The locations are shown on Figure 1-1. Transect 9 was conducted entirely within public right-of-way due to the density of the built environment, and limited access to properties near the transect.

Sediments retrieved in the continuous core borings included near-surface thin bedded clays and massive sandy silt-silty sand. Radiocarbon dating of charcoal samples was performed, with dates ranging from 8,000 to 25,100 years Before Present (BP) at depths ranging from 8 feet to 48 feet below ground surface.

Based on these data combined with the data from the prior investigations by Metro and others, a system of faults are interpreted as presented in the Section 2 Fault Investigation report. Many of the fault strands are found to be Holocene active.

2.12 CGS Geologic Maps (CGS 2014 and 2016)

The California Geological Survey has published revised geologic maps of the Los Angeles 30 x 60 Minute Quadrangle that include the Century City and Beverly Hills area. The maps, although not produced for use in surface fault rupture hazard evaluation or seismic shaking hazard evaluation, depict a revised location of the Newport Inglewood Fault in the Century City/Beverly Hills area (Campbell et al. [CGS] 2014, 2016). The maps show the Newport Inglewood fault extending northward into Beverly Hills east of the location of previous CGS maps. No additional subsurface investigations were conducted by CGS as part of the production of these maps; the maps were produced by interpretation of Lidar aerial photographs and review of publications including most of the publications listed within this memorandum. The Section 2 WPLE fault investigation report was not published in that time frame, and therefore the results were not available to the CGS for their evaluation for inclusion in the 2016 map.

3.0 REFERENCES

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